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An Experimental Approach to Study on Small Types of Hydrogen Generators

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Abstract: Two small types of hydrogen generators: STHG 1 and STHG 2 are constructed with the four steps of experimental procedures as: (i) Collecting the required materials, (ii) Constructing STHG 1 and STHG 2, (iii) Operating the electrolysis process and (iv) Testing the hydrogen gas. Hydrogen evolved from STHG 1 is tested as a flame and that from STHG 2 is put into the balloon to launch are studied.
Keywords: hydrogen, STHG, electrolysis, flame, balloon

1. INTRODUCTION

Hydrogen does not occur freely in nature. It can be modified by fossil fuel or by natural gas. The usage of Hydrogen will affect significant social, economical and environmental which will impact.

Hydrogen is a chemical element with chemical symbol H and atomic number 1 with an atomic weight of 1.008. Hydrogen is the lightest element on periodic table. Its monoatomic form (H) is the most abundant chemical substance in the Universe, constituting roughly 75% of all baryonic mass. Hydrogen gas is highly flammable and will burn in air at a very wide range of concentrations between 4% and 75% by volume. At standard temperature, hydrogen is a nontoxic, nonmetallic, odourless, tasteless, and colourless. The explosion of hydrogen is stronger than the other fuels.

Electrolysis is the decomposition of water (H2O) into oxygen (O2) and hydrogen (H2) due to an electric current being passed through the water. The reaction has a standard potential difference of - 1.23V, meaning it ideally requires a potential difference of 1.23 volts to split water. The technique can be used to make hydrogen fuel (hydrogen gas) and breathable oxygen; though currently most industrial methods make hydrogen fuel from natural gas instead.

A DC electrical power source is connected to two electrodes or two plates (typically made from some inert metal such as platinum, stainless steel or iridium) which are placed in water. Hydrogen will appear at the cathode (where electrons enter the water) and oxygen will appear at the anode. The efficiency of electrolysis is increased through the addition of an electrolyte (such as salt, an acid or a base) and use of electro catalysts.

Equations

$$2H_2O \rightarrow 2H_2 + O_2$$

Reduction at cathode:

$2H^+ (aq) + 2e^- \rightarrow H_2 (g)$

Oxidation at anode:

$2H_2O(l) \rightarrow O_2(g) + 4H^+ (aq) + 4e^-$

The hydrogen by electrolysis is the purest quality more than the other processes.

Table1. Methods of Hydrogen Production

Primary Energy	Hydrogen production method	Material Resources
Electrical Energy	- Electrolysis - Plasma arc decomposition	- Water - Natural Gas
Thermal Energy	- Thermolysis - Thermo-catalysis - Thermo-chemical processes	- Water - H_2S cracking - Biomass conversion - Water splitting - Gasification - Reforming - H_2S splitting
Photonic Energy	- PV electrolysis - Photo-catalysis - Photo-electrochemical method - Bio-Photolysis	- Water - Water - Water - Water

Even though hydrogen is very expensive to produce and to store, it is pollution-free energy and creates drinkable water. In the end result the usage of hydrogen and fuel cell technologies can enhance and improve different aspects.

The present work aims:

To produce hydrogen gas through the water electrolysis

Objectives are:

To construct Small Type Hydrogen Generators – STHG 1 and STHG 2

To operate electrolysis process using STHG 1 and STHG 2

To analyze the behavior of the evolved hydrogen gas

To apply the gas as the fuel to solve future energy needs

2. EXPERIMENTAL PROCEDURES

2.1 Design and Construction of STHG 1

To construct the STHG 1, plastics bottles are used for the feasible and economy. Its shape is chosen as a cylinder base and cone at the top. The diameter of the cylinder is about 9 cm and the length is about 45 cm. Two plastic bottles are used to get this type. For cylinder base, 37 cm of plastic bottle body is cut and 10 cm of cone shape is cut from the top of the other plastic bottle. These two pieces will be fitted after putting the anode and cathode nodes.

Electrolysis process can be used to generate hydrogen and so to run this process there will be needed cathode node and anode node in the STHG 1. For this work, razors (Topaz blades materials) are chosen and 30 blades are used for STHG 1. The conduction area per blade is about 19.4 cm^2. Plastic pipes are used to connect these blades. The distance between the razors, about 1 cm is suitable for the process.

To prepare the nodes, the blades are firstly unsharpened. And the wires are connected in each blade using the soldering iron for fastness. Later, the blades are fixed at the two pipes and then put them into the cylinder base bottle. Two ends of wires are also soldered at the outside of the body. These ends will be joined to the battery. After these steps, the top cone part is fitted to be the STHG 1. IV set is fit at the top of the cone for the emit hydrogen gas. For fastening the fitting, the glue gun is used and the joints are carefully sealed. The construction of STHG 1 is shown in Figure 2.1.

2.2 Design and Construction of STHG 2

For the use of electrolyte, sodium hydroxide NaOH, in the electrolysis process, STHG 2 is designed and constructed. Plastics box (12cm × 13cm × 19cm) is chosen and fitted with two L shape steel bars. One end of the bar is inside and the other is outside from openings of the bottom of box. These openings fitted with the L bars are sealed by using the glue gun.

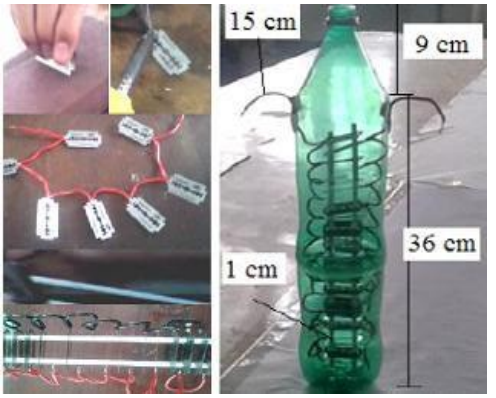

Figure 2.1 Construction of STHG 1

For the electrolysis process, the cathode and anode nodes are needed. Stainless steel plates are used for the nodes. 12 numbers of steel plates, 8cm × 3cm, are cut and lunched on them. For each node, 6 numbers of plates are used and joined to the L bar. 3 numbers of plates are placed on one side of L bar. These are fitted with the screw. Distance between the nodes is 8cm apart.

The two nodes are covered with the plastic bottles which cut the bottom. At the top of the bottle, IV set is fit for the emitted gas. Two plastic bottles are used for the capture of water vapour and other impurities in exit gases. The constructed STHG 2 is shown in Figure 2.2.

2.3 Production of Hydrogen

After constructing the hydrogen generators, test their performance for hydrogen production. Before testing, electrolyte solution is prepared for the electrolysis.

Figure 2.2 Construction of STHG 2

2.3.1 Preparation of Electrolyte Solutions

Sodium chloride is weighed and mixed with the distilled water to get 3% sodium chloride solution. It is for the electrolysis process of STHG 1. Sodium hydroxide is also weighed and mixed with the distilled water to be 5 % sodium hydroxide solution.

2.3.2 Electrolysis Process in STHG 1

Sodium hydroxide solution is added to the STHG 1. And it is joined with the battery and started the electrolysis process. After 30 seconds, the gas bubbles are appeared in the STHG 1. Waiting 3 minutes, the hydrogen gas is emitted from the exit pipe.

2.3.3 Electrolysis Process in STHG 2

Sodium hydroxide solution is put into the STHG 2 and connected the cathode node to – terminal of battery and anode node to the + terminal of the battery. Hydrogen (H_2) is collected at the cathode node and oxygen (O_2) is collected at the anode node. The gas bubbles are appeared at the starting time of the analysis and they are collected with the balloon. The flowchart of the experimental studies is given in Figure 2.3.

STHG 1 and STHG 2 have the following parts/ modules.

Electrolyser: Housing and Electrodes

Power Supply: Battery (12 volts)

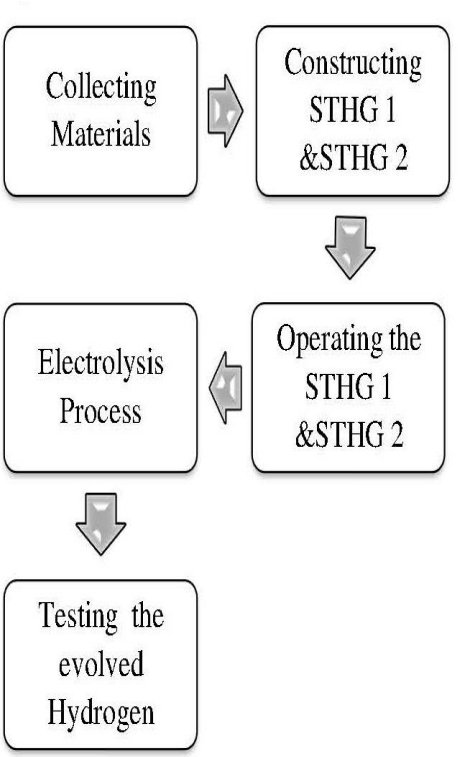

Figure 2.3 Flowchart of the Experimental Studies

The electrolyser housing is made up of plastic materials. The electrolyser contains the electrode for the process of electrolysis. The electrode for STHG 1 is prepared with the Topaz blades and small wires. For STHG 2, stainless steel plates are used to act as an electrode. Sodium chloride and sodium hydroxide are used as the electrolyte solution for the electrolysis process. Power supply used is the battery (12 volts). Hydrogen evolved from STHG 1 is tested as a flame and that from STHG 2 is put into the balloon to launch.

3. RESULTS AND DISCUSSION

In this project, STHG 1 is constructed for the use in the electrolysis process. One important use of electrolysis is to produce hydrogen. The reaction that occurs is:

$$2H_2O\ (l) \rightarrow 2H_2\ (g) + O_2\ (g)$$

Electrolysis of water can be achieved in STHG 1 where electricity from a battery is passed through a salt water solution. Electrolysis of an aqueous solution of sodium chloride produces the minute amounts of the aqueous sodium hydroxide and chlorine.

The following ionic equations may occur for the electrolysis of sodium chloride solution.

$$2Cl^- \rightarrow Cl_2 + 2e^-$$

$$2H_2O + 2e^- \rightarrow H_2\ (g) + 2OH^-\ (g)$$

These equations show the oxidation at the cathode node of the STHG 1 and release of chlorine gas and the reduction at the anode node and release of hydrogen gas in STHG 1. From the overall ionic equation, the products are Cl2, H2 and OH−. Cl2 and OH− are soluble in water and so it may be estimated that the evolved gas from STHG 1 is Hydrogen gas only. To test this, the syringe is used to ignite the exit gas. The hydrogen gas flame from it can be seen in Figure 3.1. The flame is small at the 3 minutes after starting the process. The more times the gas evolved, the greater the flame. The sense of hydrogen to hand is cool.

Figure 3.1 Hydrogen flame from STHG 1

It can be seen that the deposit of the aqueous salt solution are increasing with the operating time. The color of the solution is changed from the transparent to nearly black. After running the electrolysis, the cathode and anode nodes of the

of the STHG 1 are covered with the deposit and the thickness of the blades are also decreased. The color changed problem is avoided by using other type of electrolyte solution. But the design of STHG 1 is prepared for the salt solution. It has one exit (opening) for hydrogen gas. When the other electrolyte solution such as sodium hydroxide is used in STHG 1, it may explode for combining with oxygen to evolved hydrogen gas. Sodium hydroxide solution is used as an electrolyte in STHG 2. The following reactions take place inside the STHG 2.

$4\ H_2O \rightarrow 4H^+ + 4OH^-$

$4H^+ + 4e^- \rightarrow 2H_2$

$4OH^- \rightarrow O_2 + 2H_2O + 4e^-$

$2H_2O \rightarrow O_2 + 2H_2$

The node joined with the + terminal of the battery is named as cathode node and also the other node is called anode node. The hydrogen gas is collected at the anode node and the emit oxygen is at the cathode node. From the stoichiometric equation, the emitted hydrogen is about two times of the oxygen evolved. In testing the STHG 2, it can be seen clearly that the gases are not emitted at the same time. The gas bubbles are alternately appeared at the nodes.

The performance test of STHG 2 is shown in Figure 3.2. The estimated evolved gas rate of oxygen and hydrogen are 10 cm3/min and 20 cm3/ min respectively and shown in Figure 3.3.

Figure 3.2 Performance test of STHG 2

Battery consumption of STHG 1 and STHG 2 during the electrolysis process is shown in Figure 3.4. Comparing these, STHG 2 is less consumption of battery power than STHG 1. It may depend upon the type of the electrolyte solution and design of hydrogen generator.

For 30 min operation, about 4 volts of battery power is consumed by STHG 1 but STHG 2 is needed only about 1 volt.

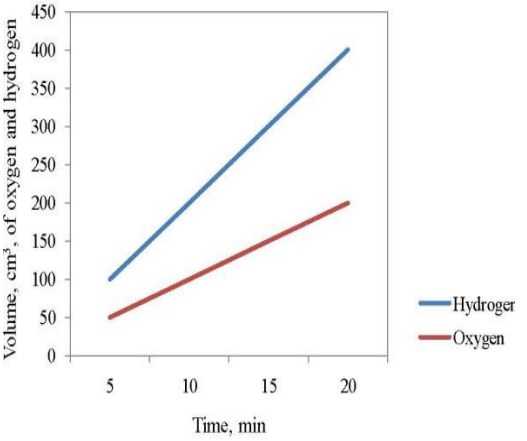

Figure 3.3 Volume of output gases from STHG 2

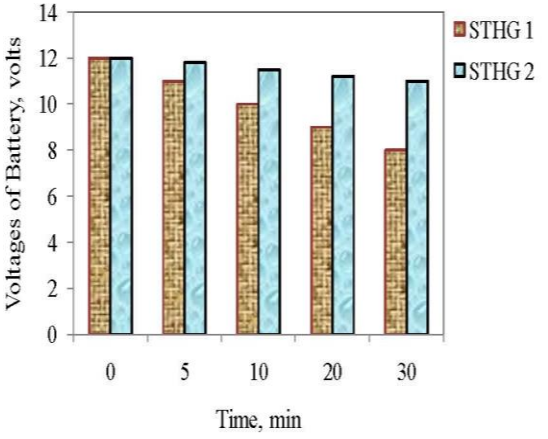

Figure 3.4 Battery consumption during the electrolysis process

4. CONCLUSION

Electrode is an important component in electrolysis process as it separate water molecules to hydrogen ions and oxygen ions. As well, the STHG 1 and 2 are designed to operate the electrolysis process. Using the Topaz blades for STHG 1 and the stainless steel plates for STHG 2, the electrodes are constructed to meet outlined specifications.

The key issues in the design, readily, easily and portability are considered. These generators are designed to produce hydrogen gas and STHG 1 contains the one opening for the evolved gas and so the product hydrogen gas is not pure, but STHG 2 has no problem.

Finally, electrolysis process operates to produce the hydrogen gas. During the process, it can be observed that the emitted gas depends on the amount of electrolyte and the conduction area of the electrodes.

Overall, the objectives of the project; to produce the hydrogen gas, are met. As well, experience is gained in the use of tools to design and construct the STGH 1 and STGH 2. Hence, the small types of hydrogen generators can be constructed to produce the hydrogen.

5. RECOMMENDATION

Recommendations for further research works are outlined as follow.

- The construction of large scale types of hydrogen generators to produce a lot of hydrogen gas
- Evaluating the properties of the hydrogen and Applying the hydrogen gas for the fuel requirements.

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